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SAND AND GRAVEL RESOURCES OF TAZEWELL COUNTY, ILLINOIS

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ABSTRACT

Tazewell County has large amounts of sand and gravel, most of which were deposited by meltwater from glaciers during the Pleistocene Epoch or Ice Age. These deposits are found principally in valleys that served as major channels for the meltwater, in the vicinity of the Illinois River, Mackinaw River, and Farm Creek. Smaller amounts are found in deposits from glacial meltwater away from these streams, in sand dunes, and in stream alluvium.

Geographical locations of the deposits have been mapped on the scale 1:62,500.

INTRODUCTION

Purpose of Study

Increasing amounts of sand and gravel are required for construction in the growing urban areas of Illinois and for improvement of the state highway network. In response to the need for information regarding these resources, the Illinois State Geological Survey is engaged in a program to evaluate or, in places, re-evaluate the sand and gravel resources of the state. This report, covering Tazewell County (fig. 1), is a part of that program.

Pekin and East Peoria, and their suburbs, cover extensive sand and gravel deposits, which therefore are unavailable for commercial exploitation. As these cities continue to grow, resources remaining in the county will become increasingly important as reserves to supply the needs of the area. This report points out potential sand and gravel sources whose preservation for future use should be considered in land use planning.

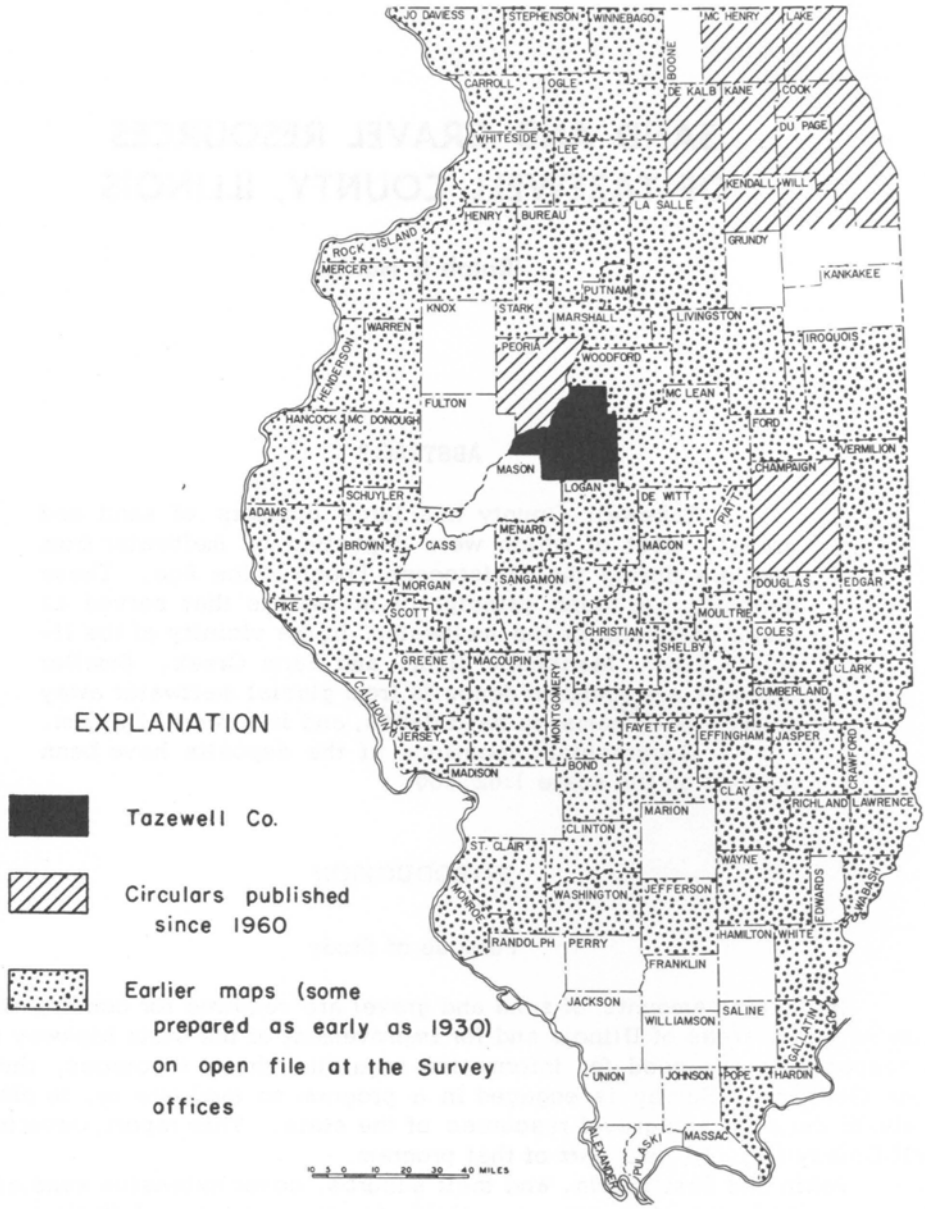

Figure 1 - Index map showing Tazewell County and other areas where sand and gravel resources have been mapped.

Previous Investigations

A number of earlier investigations relate to the geology of Tazewell County and touch on the sand and gravel resources, though mostly to a minor degree. The earliest discussion of the geology of Tazewell County was by Bannister (1870). Leverett (1899) included Tazewell County in his study of the Illinois glacial lobe. The geography of the Middle Illinois Valley, including part of Tazewell County, was discussed by Barrows (1910). Udden (1912) described the geology and mineral resources of that portion of Tazewell County lying within the Peoria Quadrangle. The Tazewell County soils, which offer clues to the nature of the underlying material, were mapped and described by Hopkins et al. (1916). Willman (1942) determined the mineralogical composition of several Tazewell County sand samples as part of his study of feldspar in Illinois sands. Horberg et al. (1950) and Walker et al. (1965) discussed the sand and gravel deposits of parts of Tazewell County in relation to their value as sources of water. Wanless (1957) described the geology and mineral resources of the Glasford Quadrangle in Tazewell County.

Several excellent outcrops of the glacial deposits in Tazewell County have helped unravel the glacial history of Illinois; these outcrops are described and interpreted in papers by Leighton (1926, 1931, and 1965), Horberg (1953), Frye and Willman (1960), and Frye, Glass, and Willman (1962, pl. 1).

The geology and mineral resources of the area along the Illinois Waterway were described by Lamar et al. (1935) in an unpublished report on open file at the Illinois State Geological Survey. Several outcrops of glacial materials are described in an unpublished study of engineering properties of the materials by Smith (1961), also on open file. Another unpublished report on open file, by H. A. Sellin (1930), under the direction of George E. Ekblaw, discusses the glacial deposits, including sand and gravel resources, of Tazewell County.

Acknowledgments

The assistance of Richard C. Anderson, in the field interpretation of the glacial geology of Tazewell County, is gratefully acknowledged.

TYPES OF DEPOSITS

General Statement

Most of the surface materials of Tazewell County are unconsolidated and were deposited either by glaciers that once covered the county, by glacial meltwater, by wind, or by streams after withdrawal of the glaciers. The materials deposited by glacial ice or meltwater are referred to as glacial drift. The materials deposited by wind or by postglacial streams are indirectly the result of glacial activity, for the materials of which they are composed were derived from glacial drift. Most of the sand and gravel of Tazewell County was deposited by glacial meltwater, although some was deposited by postglacial streams, and some sand was deposited by the wind.

Because the distribution and character of the sand and gravel deposits in the county are closely related to glacial activity, knowledge of the major features and events of the Pleistocene Epoch is needed. Most of the glacial drift exposed at the surface in Tazewell County was deposited during the fourth, or most recent, major glacial advance in North America, termed the Wisconsinan Stage. Glacial drift deposited during the third glacial advance, the Illinoian Stage, occurs at the surface in west-central and south-central Tazewell County (fig. 2) and also is exposed under Wisconsinan drift in parts of the Mackinaw, Farm Creek, and Sugar Creek Valleys. Deposits left by pre-Illinoian glaciers are known in Tazewell County from wells and from small outcrops along some of the deeper valleys.

Most of the sand and gravel in Tazewell County is of Wisconsinan age. Sand and gravel of Illinoian age, and possibly older, crops out along some of the deeper valleys but is overlain by thick overburden under the uplands.

The deposits of Tazewell County were investigated by (1) study of land forms, which offer clues to the nature of the underlying material, (2) examination of the materials in natural and man-made exposures and in shallow hand-auger borings, and (3) study of well logs.

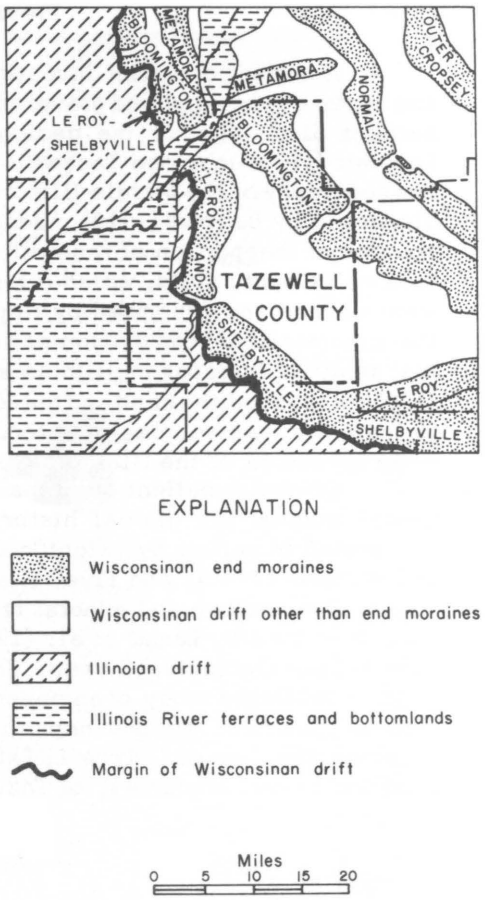

Figure 2 - Map of glacial deposits in Tazewell County and environs.

Glacial Till

The poorly sorted mixture of materials deposited directly by a glacier is called till. It consists of bedrock fragments and unconsolidated material that were picked up and transported by the moving ice and partially broken and ground into finer fragments during the process. The till of Tazewell County is principally clay and silt but contains some sand, pebbles, cobbles, and boulders. It is massive rather than bedded.

When the forward movement of a glacier was balanced by melting, the front of the glacier remained approximately stationary and the material carried by the ice accumulated, mainly as till, as a ridge along the ice front. This ridge is known as an end moraine. Several end moraines stretch across Tazewell County in a

general northwest to southeast direction (fig. 2 and pl. 1). These were formed by ice that came from the northeast during Wisconsinan time. The large amounts of earth materials and meltwater released at the ice front while an end moraine was being formed were responsible for the formation of many sand and gravel deposits. Most of the sand and gravel deposits of Tazewell County were formed this way, either while the glacial front was stationary within the county, or while it was outside the county, but still within the drainage basin of which Tazewell County forms a part.

When a glacier melted faster than it moved forward, the glacial front receded, leaving behind a relatively flat or gently undulating sheet of till called a ground moraine. Few if any of the sand and gravel deposits of Tazewell County were formed while the glaciers were retreating and forming ground moraines.

Water-Laid Glacial Drift

Water-laid glacial drift is the material deposited by glacial meltwater. The materials are the same as those found in glacial till, because they were carried by the ice before being picked up by meltwater. Water-laid glacial drift can be distinguished from glacial till by its stratification or bedding and by the fact that it consists principally of materials of one or two size grades. The particle size of water-laid drift is determined primarily by the velocity of the depositing stream, with coarse deposits being formed by fast-flowing water. The coarsest and most poorly sorted material is generally found near the melting front of a glacier. Deposits become progressively finer and better sorted away from the ice front. Most of the water-laid glacial drift of Tazewell County is sand and gravel, although beds of clay and silt occur locally.

The water-laid glacial drift of Tazewell County occurs chiefly as deposits called outwash because it was laid down beyond the margin of the ice. In Tazewell County, outwash occurs in flat areas bordering end moraines, called outwash plains, and as deposits confined within valleys leading away from end moraines, called valley trains. The valley trains originally filled the valleys to a certain level from side to side, but later stream erosion removed large parts of the fillings, leaving flat-surfaced remnants, called terraces, along the streams. Terraces are the most important sources of sand and gravel in Tazewell County.

In addition to outwash, water-laid glacial drift occurs in a few places in Tazewell County as hills, called kames, composed largely of sand and gravel that was deposited in contact with melting ice. Kames are recognized by their topographic form, large variations in particle size from bed to bed, and irregular bedding. Their small size and the common occurrence of till masses or beds limit their value as sand and gravel resources.

Wind-Laid Deposits

Wind blowing across valley train deposits in the Illinois Valley heaped some of the sand into dunes on the valley terraces and on some of the adjoining uplands. Silt also was blown onto the uplands where it accumulated to thicknesses of 5 to

Stage	Deposits			
	In Illinois Valley	In Mackinaw Valley upstream from Illinois Valley bluffs	In other valleys	On uplands
Recent and Wisconsinan	Alluvium Sand dunes	Alluvium	Alluvium	Sand dunes
Wisconsinan	Low-level (Bath and Beardstown) terraces			
	Intermediate-level (Havana and Manito) terraces	Low-level terrace	Minor terraces (age uncertain)	
	High-level (Normal-Cropsey-Bloomington) terrace	Intermediate-level (Normal-Cropsey-Bloomington) terrace	Minor terraces (age uncertain)	
		Minor (Inner Bloomington) terraces	Minor (Inner Bloomington) terrace in Farm Creek Valley	Inner Bloomington Moraine
		High-level (Outer Bloomington) terrace	High-level (Outer Bloomington) terrace in Farm Creek Valley	Outer Bloomington Moraine and outwash plains
			Minor (Bloomington) terraces in Sugar Creek Valley	LeRoy Moraine, outwash and kames Shelbyville Moraine and outwash
				Loss
Illinoian				Till
Illinoian and pre-Illinoian (?)				Sand and gravel cropping out beneath till in valley bluffs

(?) — High-level (Normal-Cropsey-Bloomington) terrace in Illinois Valley

(?) — Intermediate-level (Normal-Cropsey-Bloomington) terrace in Mackinaw Valley upstream from Illinois Valley bluffs

(?) — High-level (Outer Bloomington) terrace

Figure 3 - Correlation chart of glacial deposits of Tazewell County.

more than 20 feet. The silt, called loess, is thickest on the areas of Illinoian till adjacent to the Illinois Valley. It comprises at least part of the overburden on most of the sand and gravel deposits in Tazewell County.

Alluvium

The alluvium occurring in Tazewell County was deposited by streams after the withdrawal of the glaciers. It is generally finer grained and more clayey than the glacial outwash in the county. For these reasons, it is generally a less valuable source of sand and gravel than outwash.

DISTRIBUTION OF SAND AND GRAVEL

The sand and gravel resources of Tazewell County are discussed in order of age, beginning with the oldest deposits, except where a discussion by type of deposit or by geographical location is more convenient. For example, terraces in the Illinois Valley west of the bluffs that form the edge of the till uplands are discussed in sequence, as are terraces along the Mackinaw River upstream from the Illinois Valley bluffs, even though certain terraces in the Illinois Valley are of the same age as terraces along the Mackinaw River. The Illinois Valley bluffs are shown on plate 1, the resources map. The age relations of the glacial deposits of Tazewell County are shown in figure 3.

In the legend on plate 1, the various patterns indicating sand and gravel resources are numbered in order of probable importance. Because the map and text sequences are not in the same order, the various deposits have been numerically identified both in the text and on the map legend as a means of reference.

Locations of deposits sampled and results of sieve tests and pebble counts are shown in tables 1, 2, and 3 respectively.

Sand and Gravel Cropping Out Beneath Glacial Till in Valley Bluffs (Illinoian and Pre-Illinoian Outwash)

(Map pattern 8) Sand and gravel crops out beneath glacial till along the bluffs of Farm Creek and its tributaries and along the Illinois River bluffs for several miles northeast and southwest of East Peoria. It occurs as a sheet of material of irregular shape and thickness resting on bedrock. It underlies till of Illinoian age and is considered to be mainly of that age, but in some outcrops the lower part may be pre-Illinoian (Horberg, 1953, p. 47-48). No Nebraskan drift has been identified in the county, and thus the pre-Illinoian drift is probably all Kansan in age.

The sand and gravel thins out against bedrock hills south of Farm Creek and is not present in some of the tributary valleys extending south from Farm Creek and east from the Illinois River in the northwestern part of T. 25 N., R. 4 W. To the north, the top of the sand and gravel descends in elevation and passes below valley level. To the east, the valley floor of Farm Creek rises above the top of the sand and gravel.

The thickness of the sand and gravel increases northward and westward from the bedrock hills south of Farm Creek. In many places the base of the sand and gravel is below valley level, so that the total thickness is uncertain. The maximum thickness exposed in the valley bluffs is about 50 feet along the Illinois River in sec. 33, T. 26 N., R. 4 W.

TABLE 1 - LOCATION OF SAND AND GRAVEL SAMPLES FROM TAZEWELL COUNTY

Sample number	Location						Thickness sampled (feet)	Source	Kind of deposit
	¼	¼	¼	Sec.	T.	R.			
1		SE	SE	28	26 N.	4 W.	20	Gravel pit	Sand and gravel cropping out beneath till in valley bluffs
2	NE	NE	NE	36	24 N.	5 W.	12	Cut bank	Upland sand and gravel in front of Shelbyville Moraine
3		NW	SW	35	26 N.	4 W.	18	Gravel pit	High-level terrace in Farm Creek Valley
4	NE	SE	SE	18	24 N.	2 W.	15	Gravel pit	High-level terrace in Mackinaw Valley upstream from Illinois Valley bluffs
5	SE	NW	SW	35	25 N.	2 W.	10	Gravel pit	Intermediate-level terrace along Mackinaw River upstream from Illinois Valley bluffs
6	NE	SE	SE	4	23 N.	3 W.	18	Gravel pit	Intermediate-level terrace along Mackinaw River upstream from Illinois Valley bluffs
7		SE	NW	18	23 N.	4 W.	16	Gravel pit	High-level terrace in Illinois Valley
8		SE	SW	22	23 N.	5 W.	15	Gravel pit	High-level terrace in Illinois Valley
9		SE	NE	26	25 N.	5 W.	15	Gravel pit	Intermediate-level terraces in Illinois Valley
10		SE	NE	20	24 N.	6 W.	20	Gravel pit	Intermediate-level terraces in Illinois Valley
11	NW	NW	NW	34	24 N.	5 W.	10	Road cut	Sand dune
12	SW	SE	SW	2	23 N.	7 W.	7	Sand pit	Sand dune

TABLE 2 - SCREEN ANALYSES[1]
(Percent retained)

Sieve	Sample number											
	1	2	3	4	5	6	7	8	9	10	11	12
2½ inch				0.7	3.1		1.2		3.5			
2 inch				0.5	1.7		0.6	1.1	0.0			
1½ inch	1.0	1.8	0.6	1.5	1.6	1.3	0.7	3.9	2.5	0.6		
1 inch	0.7	3.3	2.3	4.2	3.8	2.4	4.4	2.8	6.1	2.2		
3/4 inch	1.2	4.2	3.9	5.3	5.3	3.7	4.6	4.1	8.1	2.6		
½ inch	1.2	4.5	5.0	4.6	3.0	4.2	5.0	4.4	9.1	2.5		
3/8 inch	2.0	5.9	8.4	6.8	6.9	6.9	7.6	8.0	10.9	3.1		
3 mesh	2.0	6.5	8.7	6.9	4.9	7.2	7.9	5.2	9.5	2.9		
4 mesh	2.6	6.2	8.8	8.0	6.6	8.6	8.3	6.9	9.3	3.0		
6 mesh	2.6	5.0	7.2	3.7	6.1	6.0	10.2	7.2	5.6	4.5		
8 mesh	5.5	3.0	5.9	3.3	7.4	6.8	10.5	7.0	4.4	7.8		
10 mesh	5.5	2.9	5.9	3.5	6.3	5.5	10.3	6.7	3.4	8.7	0.1	0.1
14 mesh	4.8	3.0	5.9	4.5	6.0	5.6	8.1	6.4	2.7	7.7	0.5	0.4
20 mesh	4.5	3.2	5.4	5.7	5.9	5.2	5.6	6.1	3.3	6.1	1.1	1.7
28 mesh	10.2	5.6	7.3	8.7	8.3	7.5	5.5	9.3	6.1	8.3	9.2	9.7
35 mesh	19.4	7.8	7.2	9.6	8.2	8.3	4.2	8.6	6.9	9.0	27.2	24.3
48 mesh	17.6	12.4	8.3	10.0	10.0	11.1	2.4	7.3	6.0	13.8	30.6	39.4
65 mesh	11.3	10.1	4.9	6.0	3.4	4.9	1.2	2.8	1.6	11.1	11.9	13.7
100 mesh	6.5	7.2	2.3	3.9	1.0	2.9	0.4	1.3	0.6	6.0	9.9	6.3
150 mesh	0.9	2.6	0.6	1.2	0.3	1.2	0.1	0.3	0.2	1.0	5.2	2.2
200 mesh	0.1	1.2	0.3	0.5	0.1	0.6	0.1	0.1	0.1	0.1	2.5	0.7
270 mesh	0.1	0.6	0.1	0.3	0.1	0.2	0.0	0.1	0.0	0.0	0.8	0.2
Pan	0.2	3.0	0.8	0.9	0.4	0.6	0.2	0.3	0.3	0.2	0.9	0.5
Total	99.9	100.0	99.8	100.3	100.4	100.7	99.1	100.0	100.2	101.2	99.9	99.2
+1 inch	1.7	5.1	2.9	6.9	10.2	3.7	6.9	7.8	12.1	2.8		
+4 mesh	10.9	32.4	37.7	38.5	36.9	34.3	40.3	36.4	59.0	16.9		
-4 mesh	89.0	67.6	62.1	61.8	63.5	66.4	58.8	63.6	41.2	84.3	99.9	99.2

[1]Sieve tests by William C. Butler - October 1965

TABLE 3 - PEBBLE COUNTS OF GRAVEL SAMPLES
(Percent by number of pebbles)

Sample number	1		2		3		4		5		6		7		8		9		10	
Size (inches)	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8	3/4 x 1/2	1/2 x 3/8
Dolomite	29	46	38	40	46	50	48	55	44	46	51	46	44	41	44	47	43	39	63	59
Limestone	5	11	9	14	14	16	11	15	13	13	8	13	14	22	12	11	16	19	17	9
Weathered carbonate rock	3	2	2	5	2	5	6	4	4	5	2	5		1	2	2	1	2	4	2
Chert	7	12	18	16	11	9	8	7	15	11	9	9	7	11	9	10	19	15	4	10
Shale		1		1	1	1	1	1		1	1	1								
Sandstone and siltstone	7	5	12	9	10	6	9	5	10	9	8	8	4	4	8	5	5	8		2
Ironstone concretions		1	1	2	1	1	5	2	2	1	2	2	1	1	2	2	1			1
Dark-colored igneous	3	2	6	3	2	2	4	3	2	1	5	1	3	4	2	4	1	2	4	6
Granitic igneous	2	2	4	2	4	2	1	4	1	4	7	4	3	4	1	3	7	4	6	4
Rhyolitic igneous		1		1			1		1	1			1	1			2	1		2
Quartz			1	1		1			1	2	1	1			1	2		2		1
Quartzite		1	3	2	1	1	3	1	2	2	1	3	1	2	3	1	3	3	2	
Gneiss		1	1		1		1	1	1	1	1	1			1	1	1	1		
Schist	2			1		1							1		1					
Graywacke	2		4	2	1	1	1	1	3	2	2	4	4	1	1	1	1	3		4
Cemented gravel	21	6	1	1	6	4	1	1	1	1	2	2	17	8	13	11		1		
Clay balls	19	9																		
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

The upper part of the deposit consists of interbedded sand and gravel, ranging from about 15 to 30 feet thick. Some coarse gravel is present. A few thin, clayey, till beds, which become thicker to the north, commonly occur, and pebble-sized balls of till, called clay balls, are present in places. In some outcrops, part of the sand and gravel is cemented. Sample 1, from the upper part of the deposit, is a pebbly sand (table 2) containing clay balls (table 3).

The lower part of the deposit consists largely of sand at least 30 feet thick in places, with the base not exposed.

The availability of the sand and gravel is limited by the thick overburden of clayey till that is present a short distance back from the bluff outcrops. Moreover, much of the outcrop area is urban or residential.

Upland Sand and Gravel
(Shelbyville, LeRoy, and Outer Bloomington Outwash Plains)

(Map pattern 9) Several areas of sand and gravel occur along the western or front edges of the Shelbyville and LeRoy Moraines in west-central Tazewell County. These probably are outwash plains, dissected and grading into terraces, of Shelbyville and LeRoy age. In addition, several small outwash plains occur along the front edge of the Outer Bloomington Moraine in northeastern Tazewell County.

The most extensive sand and gravel area lies about 2 miles southeast of South Pekin. Westward-dipping cross-bedding, westward decrease in grain size, and location in front of the Shelbyville Moraine suggest that the material is Shelbyville outwash. Sand and gravel 10 to 15 feet thick is exposed at several places in this area. The base of the outwash is not exposed along the western edge of the area, and here the thickness may be considerably greater than 15 feet. Overburden consists of about 10 feet of silt and soil, plus as much as 20 feet of dune sand locally. The material includes some coarse gravel adjacent to the moraine front, but in the northwestern part of the area only sand and fine gravel are exposed. Sample 2 is a sandy gravel (table 2) from near the moraine front; its lithologic composition is shown in table 3.

Several small remnants of sand and gravel occur in and just south of Creve Coeur, southwest of East Peoria. These probably are Shelbyville-LeRoy outwash but may be terraces of Bloomington age. The greatest thickness of sand and gravel is about 15 feet. Some coarse gravel is present in the northern part of the area, but in the southern part only sand and fine gravel are exposed. Much of the area, however, is residential.

Several small patches of LeRoy outwash occur from 2 to 3 miles southwest of Dillon in T. 23 N., R. 4 W. The maximum thickness of the sand and gravel is about 15 feet. No more than 3 feet of sand and gravel was seen in the largest area, in the SW$\frac{1}{4}$ sec. 8, T. 23 N., R. 4 W.

Four relatively small Outer Bloomington outwash plains were found in the SE$\frac{1}{4}$ sec. 15, T. 25 N., R. 3 W.; E$\frac{1}{2}$ sec. 12, T. 24 N., R. 3 W.; sec. 28, T. 24 N., R. 2 W.; and NE$\frac{1}{4}$ sec. 26, T. 24 N., R. 2 W. Only the uppermost 1 or 2 feet of any of these deposits could be observed and therefore the thickness of sand and gravel in them is uncertain, but probably less than 15 feet in most places. The driller's log of a well in the NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 28, T. 24 N., R. 2 W., records 20 feet of sand and gravel.

The overburden of these four areas consists of 5 to 10 feet of silt and soil. The uppermost few feet of the deposits varies from sand to sandy gravel.

Kames

(Map pattern 13) Several kames or kamelike hills of LeRoy age are found west of Dillon in T. 23 and 24 N., R. 4 W. These are small hills 10 to 30 feet above the surrounding area. In the best exposures, sand and gravel is overlain by till. The sand and gravel is probably not more than 15 feet thick in any of these kames. The small size of these deposits and their close association with till limit their value.

A single large kame or kamelike hill of LeRoy age occurs in the southeastern corner of the county, in secs. 25 and 26, T. 22 N., R. 2 W., and rises about 50 feet above the surrounding countryside. Hand-auger borings reveal that pebbly sand immediately underlies the approximately 5 feet of loess and soil overburden, but it is not known if sand and gravel extend to the base of the hill.

High-Level Terrace in Farm Creek Valley (Outer Bloomington Terrace)

(Map pattern 5) The higher of two terraces along Farm Creek consists of discontinuous remnants occurring from East Peoria eastward for about 6 miles. The material was deposited by meltwater from the ice front at the time when the Outer Bloomington Moraine was being formed. In elevation, the terrace ranges from 690 feet at the easternmost point to 600 feet at East Peoria.

The sand and gravel is generally 15 to 30 feet thick but is less in some of the smaller remnants. Silt and soil, 5 to 10 feet thick, form the overburden. At the contact with the moraine, in the NE$\frac{1}{4}$ sec. 24, T. 26 N., R. 4 W., most of the sand and gravel extends beneath Outer Bloomington till, but some extends over the till.

The sand and gravel has relatively uniform characteristics throughout the area in which it occurs, with coarse gravel present. The upper 5 to 10 feet generally contains more clay than the lower part and is commonly used as road gravel. The basal foot or two is commonly cemented. Sample 3 is a sandy gravel (table 2) from one of the large pits in these deposits; its lithologic composition is shown in table 3.

These deposits in the Farm Creek Valley are the most important source of sand and gravel within 5 miles of East Peoria. However, a large percentage of the material already has been excavated, and some of that remaining is in urban areas.

High-Level Terrace in Mackinaw Valley Upstream from Illinois Valley Bluffs (Outer Bloomington Terrace)

(Map pattern 7) Sand and gravel, deposited by meltwater from the glacier that formed the Outer Bloomington Moraine, occurs as a high-level terrace along

Mackinaw River and some of its tributaries upstream from the Illinois Valley bluffs. The elevation of the terrace ranges from 670 feet at the moraine front at Mackinaw to 590 feet at the farthest downstream remnant in sec. 18, T. 23 N., R. 3 W.

In the vicinity of Mackinaw, where the terrace adjoins the Outer Bloomington Moraine, the sand and gravel is thickest; it is 20 to 25 feet thick in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 18, T. 24 N., R. 2 W. Downstream along the Mackinaw River, thicknesses vary from less than 5 to about 15 feet. Along Mud Creek and its tributaries, thicknesses of 10 to 15 feet are found. Along Little Mackinaw River, no more than 5 feet are found. Overburden consists of 5 to 10 feet of silt and soil. Where the terrace adjoins the moraine front, in the NW$\frac{1}{4}$ sec. 17, T. 24 N., R. 2 W., the sand and gravel is overlain by Outer Bloomington till.

The upper few feet of the sand and gravel in the terraces is slightly clayey, and the basal foot or two is cemented in places. Some of the gravel is coarse. The sieve analysis and lithologic composition of sample 4, a sandy gravel from the deposit at Mackinaw, are shown in tables 2 and 3.

Except for the deposits in the vicinity of Mackinaw, the Outer Bloomington terrace in the Mackinaw Valley is probably of minor present importance because of the thinness of the sand and gravel.

Intermediate-Level Terrace Along Mackinaw River Upstream from Illinois Valley Bluffs (Normal-Cropsey-Bloomington Terrace)

(Map pattern 4) An intermediate-level terrace occurs along the Mackinaw River at elevations ranging from 550 feet just above the Illinois Valley bluffs to 640 feet at the eastern boundary of Tazewell County. Downstream from T. 23 N., R. 3 W., this terrace is the higher of two terraces; upstream, it is the lower. The fact that the intermediate terrace can be traced upstream to the Normal and/or Cropsey end moraines in Woodford and McLean Counties indicates that the sand and gravel comprising the terraces is outwash deposited during Normal and/or Cropsey time. Some of the material in downstream portions of the Mackinaw Valley may be of Bloomington age.

The sand and gravel in the intermediate terrace is generally more than 20 feet thick and in places as much as 35 feet thick. The base of the sand and gravel was observed near or a few feet above stream level at several places along the Mackinaw River, where the thickness of the gravel is approximately the difference in elevation between the highest and lowest exposures. In the SE$\frac{1}{4}$ sec. 27, T. 24 N., R. 3 W., on the other hand, sand and gravel crops out down to river level. Sand and gravel does not extend down to the river level on either side of this site and thus the thickness below river level is probably small. Near the place where the terrace passes the Illinois Valley bluffs (T. 23 N., R. 4 W.), sand and gravel may extend considerably below river level. The point farthest downstream where till was observed underlying sand and gravel above river level is in the NW$\frac{1}{4}$ sec. 19, T. 23 N., R. 3 W.

On the terrace flats the overburden consists of 5 to 10 feet of silt and soil. On some of the steep slopes forming the edges of the terrace, the overburden is thinner.

No consistent variations in texture or composition of the sand and gravel were noted from one end of the area to the other. Samples 5 and 6, from upstream and central parts of the valley, and samples 7 and 8, from a correlative terrace west of the Illinois Valley bluffs, all contain from 34 to 41 percent pebbles (table 2) and are similar in lithologic composition (table 3). No consistent vertical variation was noticed except for a zone of slightly clayey sand and gravel that forms the upper few feet and a zone of boulders that forms the basal few feet.

Low-Level Terrace Along Mackinaw River Upstream from Illinois Valley Bluffs

(Map pattern 6) A low-level terrace occurs along the Mackinaw River upstream from the Illinois Valley bluffs at elevations ranging from 580 feet at the upstream limit to 530 feet just above the Illinois Valley bluffs. It probably was formed by erosion of the material comprising the Normal-Cropsey-Bloomington terrace, and it is thought to correlate with the intermediate terrace in the Illinois Valley.

The maximum thickness of sand and gravel observed in this terrace was 20 feet. The base of the sand and gravel was nowhere seen but is probably near stream level as it is in the intermediate terrace. Thus, the maximum thickness probably is less than 25 feet. A possible exception is the area near the Illinois Valley bluffs, in secs. 17 and 18, T. 23 N., R. 4 W., where sand and gravel may extend considerably below river level.

Silt and soil 5 to 10 feet thick form the overburden on this low terrace. The sand and gravel are similar in texture and composition to that in the intermediate terrace.

High-Level Terrace in Illinois Valley (Normal-Cropsey-Bloomington Terrace)

(Map pattern 2) Three major terrace levels can be recognized in the Illinois Valley west of the bluffs that form the edge of the till uplands. The highest level is found mainly south of the Mackinaw River, largely in T. 22 N., R. 5 W., and the S$\frac{1}{2}$ T. 23 N., R. 5 W., but one small area is north of the river in sec. 11, T. 23 N., R. 5 W. The surface of the terrace has an elevation of 550 feet at the point where the Mackinaw River enters the Illinois Valley and correlates with that of the intermediate terrace along the Mackinaw River upstream from the Illinois Valley bluffs, which is of Normal and/or Cropsey age. Much of the material, however, may be of Bloomington age, and older material is probably present in lower parts of the deposit. This terrace decreases in elevation to the southwest and becomes indistinguishable from the intermediate Illinois Valley terrace in the southwest part of T. 22 N., R. 5 W. Because no break in the slope is present here, all of this area is mapped as high-level terrace.

Pits expose sand and gravel down to the base of the terrace slopes, an interval of as much as 40 feet. Well records show that sand and gravel continues down to bedrock and is over 100 feet thick (Walker et al., 1965, p. 21). Only in a narrow strip adjacent to the Illinois Valley bluffs is the sand and gravel likely to be less than 40 feet thick.

Where dune sand is not present, overburden consists of 5 to 15 feet of silt, clay, and soil. However, large areas are covered by sand dunes, some of them over 40 feet high. Gravel is probably at least as deep as the dune is high. Some low, broad, sand ridges, especially those northeast of Green Valley (sec. 26, T. 23 N., R. 5 W.) are probably water-laid but would normally be considered as overburden in a gravel-producing operation.

Coarse gravel can be seen in the terrace scarp along the Mackinaw River as far west as secs. 11 and 22, T. 23 N., R. 5 W. Farther west the exposed material is finer; no pebbles over 2 inches in diameter were seen west of sec. 20. Well logs indicate that the material also becomes finer to the south. A well at Green Valley in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 26, T. 23 N., R. 5 W., penetrated 29 feet of very gravelly sand underlying 12 feet of silt and soil and overlying 74 feet of sand and slightly gravelly sand. Still farther to the south, logs of wells in secs. 14 and 15, T. 22 N., R. 5 W., record 10 to 22 feet of sand and fine gravel overlying sand and gravelly sand.

No consistent vertical variation was noted in exposures along the Mackinaw River except for a thin zone of clayey sand and gravel underlying the silt overburden. Well records indicate that the lower parts of the deposit are largely sand. Samples 7 and 8 are sandy gravels (table 2) typical of the more gravelly portions of the deposit; they contain some slightly cemented gravel (table 3).

Sand and gravel has been produced at many places along the steep slopes where the high-level terrace adjoins lower terrace levels or the Mackinaw River floodplain. Many areas along the terrace scarps remain to be developed, however, and much larger areas are available back from the scarps.

Intermediate-Level Terraces in Illinois Valley (Havana and Manito Terraces)

(Map pattern 1) The intermediate of the three major terrace levels in the Illinois Valley west of the upland bluffs is the most extensive of the three. It covers large areas in the southwestern part of the county both north and south of the Mackinaw River. Another small area, the southern tip of the Spring Bay terrace area, is found near the northwest corner of the county. This intermediate level can be divided into two levels, the Havana and Manito Terraces (Wanless, 1957, p. 148), at slightly different elevations. The Manito Terrace has an elevation of 500-520 feet or locally higher and the Havana Terrace has an elevation of 475-495 feet; the elevations do not change appreciably from north to south. The two levels are mapped together in this report. The surfaces were probably cut by the Kankakee Flood on outwash of the same age as that in the high-level terrace (Wanless, 1957).

Pits expose sand and gravel from near the top to the base of the terrace scarps, an interval of as much as 40 to 50 feet. Well records indicate that sand and gravel continues down to bedrock and is over 100 feet thick in most places (Horberg et al., 1950; Walker et al., 1965, p. 21). Only in a narrow strip adjacent to the till uplands is the sand and gravel probably less than 40 feet thick.

The overburden on the sand and gravel consists of from 3 to 10 feet of silt and soil where dune sand is not present. The lesser thicknesses of overburden are

found on the lower of the two intermediate terraces north of the sand dune area in T. 24 N., R. 6 W. Sand dunes, some over 40 feet high, cover large areas. Gravel under the dunes is probably at least as deep as the height of the dunes. Some lower, broader ridges, most notably the one along the southwest side of Lost Creek from sec. 16 to sec. 27, T. 24 N., R. 5 W., are probably sand bars deposited by the Kankakee Flood. This sand is slightly pebbly but would probably be considered overburden in most sand and gravel operations.

The relative amounts of sand and gravel in the terrace deposits vary considerably over short distances laterally. In the large pit in the NE$\frac{1}{4}$ sec. 26, T. 25 N., R. 5 W., the material, in a zone 20 feet thick, changes from primarily sand to primarily gravel in a distance of less than 100 yards. In this same pit, a bed of clayey silt thins out completely from a thickness of 7 feet in a similar distance. An exposure of 30 feet of sand and pebbly sand in a pit in the SE$\frac{1}{4}$ sec. 36, T. 24 N., R. 6 W., may be only a small area of relatively fine-grained material, for considerable amounts of gravel are found several miles to the west, north, and southeast.

Apart from local variations, the material exposed in the terrace scarps gradually decreases in grain size to the southwest. A fairly high proportion of gravel, some of it coarse, is found in the terrace scarp along the Illinois River as far south as sec. 15, T. 24 N., R. 6 W. Gravel becomes less abundant and finer southward along the Spring Lake bluffs, and the material exposed in a cut in sec. 16, T. 23 N., R. 7 W., is primarily sand with only a few thin beds of fine-grained gravel. Sample 9 is a gravel (table 2) from north of Pekin, and sample 10 is a pebbly sand (table 2) from the bluffs along Spring Lake. Their lithologic compositions are shown in table 3.

A decrease in coarseness is also found along the terrace scarp on the west side of the Mackinaw River in T. 23 and 24 N., R. 6 W. A fairly high proportion of gravel, some of it coarse, is found as far south as sec. 26, T. 24 N., R. 6 W. Near the southern edge of the county, however, the exposed material is largely sand, although wind-blown sand covering the terrace slope makes the proportion of gravel somewhat uncertain.

The intermediate terrace along the Illinois Valley is one of the most important sand and gravel deposits in the county. Much of the material has been excavated or made unavailable by urban growth in and near Pekin, but some undeveloped tracts remain near Pekin and large reserves occur south of Pekin.

Low-Level Terraces in Illinois Valley (Bath and Beardstown Terraces)

(Map pattern 3) Several areas of low-level terraces occur along the Illinois River in Tazewell County. Two levels at slightly different elevations, the Bath and Beardstown Terraces (Wanless, 1957, p. 149), can be recognized in places but are mapped together in this report. In sec. 18, T. 24 N., R. 5 W., where the two levels are well defined, the Bath Terrace has an elevation of 460 to 470 feet and the Beardstown Terrace has an elevation of 450 to 460 feet. The terraces probably were formed by waters from glacial Lake Chicago (Wanless, 1957). The upper part of the sand and gravel in the terraces may have been deposited by the Lake Chicago outlet waters, but the lower parts are probably outwash of the same age as material in the intermediate- and high-level terraces along the Illinois River.

Two small areas of low-level terrace along the north side of the Mackinaw River, in the S½ T. 23 N., R. 5 W., were probably formed by erosion of older outwash by the Mackinaw River at the same time as Lake Chicago outlet waters were forming terraces along the Illinois River. These areas and the low-level terraces along the Illinois River are mapped together on plate 1.

The scarps at the edges of the low-level terraces expose less than 20 feet of sand and gravel. However, well data indicate that sand and gravel extends down to bedrock and is over 50 feet thick in most places (Horberg et al., 1950; Walker et al., 1965, p. 21).

Overburden generally consists of 3 to 10 feet of silt and soil. Sand dunes cover the gravel in a few places, especially the area near the northwest corner of the county, but are not as numerous or as high as they are on the higher terraces.

The material comprising the terraces is exposed in only a few places. About 5 feet of coarse, boulder-bearing gravel was seen in the NW¼ NW¼ sec. 18, T. 24 N., R. 5 W. Gravel is found in the low-level terraces along the Illinois River as far south as Mason and Fulton Counties and thus probably occurs in all low-level terrace areas in Tazewell County. Much of the sand and gravel in the low-level terrace in and near Pekin either has been excavated or is in urban or residential areas.

Minor Terraces of Various Ages

(Map pattern 10) Many streams of the county have terraces--most of them relatively small--that consist of sand and gravel less than about 15 feet thick. Terraces of various geologic ages have been grouped in this category. Some of these deposits have been used locally for road gravel.

Along Farm Creek, several small terrace areas below the level of the Outer Bloomington terraces have been mapped as minor terraces. Elevations range from 690 feet near Washington to 560 feet near East Peoria. The sand and gravel is probably mainly Inner Bloomington outwash, although some of the material may be nonglacial alluvium of Wisconsinan age deposited during a temporary halt in the downcutting of the valley. No exposures of more than 10 feet of sand and gravel were seen. In the terraces in the W½ sec. 31, T. 26 N., R. 3 W., sand and gravel is less than 3 feet thick. Some of the gravel in these deposits is coarse, but much of it is clayey.

Along the West and Middle Forks of Sugar Creek terraces occur that are underlain by Outer and/or Inner Bloomington outwash. The greatest thickness of sand and gravel, about 10 feet, was seen near Armington in the S½ sec. 23, T. 22 N., R. 2 W. At this point the sand and gravel extends below stream level. A short distance upstream from here, however, the base of the sand and gravel is above stream level, so that the observed thickness of 10 feet is probably near the total thickness. The gravel is fine grained, and much of it is clayey.

In the Mackinaw Valley, terraces underlain by Inner Bloomington outwash occur along Alloway Creek; along Mud Creek, below the Outer Bloomington terrace in the same area; and along Mackinaw River, upstream from the town of Mackinaw, as the highest terrace at an elevation of 640 to 650 feet. In most of these areas, the base of the sand and gravel is above stream level, and no more than 10 feet of sand and

gravel was seen. Near the center of sec. 30, T. 25 N., R. 2 W., 15 feet of sand and gravel is exposed and extends below stream level. However, the fact that the base of the outwash is above stream level less than 3 miles downstream suggests that it is not much below stream level here. Some of the gravel is coarse, but much of it is clayey.

Other minor terraces are found in the Mackinaw Valley along Prairie Creek, Little Mackinaw River, Indian Creek, and Dillon Creek. Their low elevations, meanderlike shapes, and lack of sources at end moraines suggest that they may be alluvium deposited in response to a temporary halt in the downcutting of the Mackinaw Valley. No sand and gravel over 5 feet thick was seen; the maximum thickness is probably nowhere over 15 feet.

Sand Dunes

(Map pattern 11) Sand dunes cover large parts of the intermediate- and high-level terraces in the Illinois Valley, and a few occur on the low-level terrace. Some dunes are found on the uplands, almost all of them less than 2 miles east of the Illinois Valley bluffs.

The thickness of dune sand is probably about as great as the height of the dunes above the surrounding area. In areas of overlapping dunes, the sand may extend below the lowest areas between individual dunes. A few dunes in Tazewell County are over 40 feet high. The dunes on the terraces overlie thick sand and gravel. Most of the dunes on the uplands overlie till, but those in secs. 35 and 36, T. 24 N., R. 5 W., rest on sand and gravel. The overburden on most of the dune sand is a thin, sandy soil. Loess covers some of the easternmost sand dunes, in the southwestern part of T. 22 N., R. 4 W.

The dune sand is well sorted and primarily medium grained. Two typical examples are samples 11 and 12 (table 2). Some of the easternmost dunes on the uplands, however, consist mostly of fine-grained sand, and some dunes contain a considerable percentage of coarse-grained sand. The dunes are noncalcareous to a depth of 10 feet or more in most places. Willman (1942) describes the mineralogic composition of the dune sand.

Alluvium

(Map pattern 12) The floodplains of the Illinois River, Mackinaw River, and other streams of the county are underlain by alluvium. Alluvium also occurs in the form of fans where tributary streams discharge from the uplands onto the Illinois River floodplains or terraces.

Most of the alluvium is clay and silt. Peat and muck occur locally along the Illinois and Mackinaw Rivers. Beds of sand and gravel are found in places, but most of them are rather clayey. The percentage of gravel in the alluvium generally increases with depth. Sand and gravel relatively free of clay may occur below stream level in places. The alluvium of Farm Creek contains more sand and gravel than is usual in the county, probably because most of it was reworked from an underlying sand and gravel deposit.

The thickness of sand and gravel in the areas mapped as alluvium is much greater within the Illinois Valley than it is in most areas east of the bluffs, because in the area west of the bluffs the alluvium rests on older outwash sand and gravel that extends down to bedrock. Well data indicate that the alluvium and underlying outwash west of the bluffs are more than 50 feet thick except in areas west of Spring Lake in the southwestern part of the county, between Spring Lake and the Mackinaw River in the northern part of T. 24 N., R. 6 W., and in East Peoria near the mouth of Farm Creek in the southwestern part of T. 26 N., R. 4 W. (Horberg et al., 1950; Walker et al., 1965, p. 21).

In the Illinois River floodplain and alluvial fans, sand and gravel is reported in wells at depths of about 10 feet to more than 40 feet below clay, silt, and sand overburden. In the floodplains of Mackinaw River, Lost Creek, and Lick Creek, west of the Illinois Valley bluffs, sand and gravel occurs beneath silty or clayey alluvium at depths of less than 5 feet to at least 10 feet.

In most areas east of the Illinois Valley bluffs, the alluvium overlies till at elevations only slightly below present stream level and is less than 15 feet thick. In parts of the Farm Creek Valley, however, alluvium overlies older sand and gravel that probably extends down to bedrock. Older sand and gravel may occur below alluvium in parts of the Mackinaw River Valley, especially in the area near the Illinois Valley bluffs, and locally in other deep valleys in the county.

Upland Areas Generally Devoid of Sand and Gravel

(Map pattern 14) The areas in which sand and gravel are not mapped are underlain mainly by glacial till covered by loess. A few small areas along the Illinois Valley bluffs and in the Farm Creek Valley are underlain by bedrock. No sand and gravel of apparent commercial significance was observed in these areas, although small deposits occur locally.

Clayey sand and gravel ranging from a few inches to as much as 2 feet thick can be found on top of Wisconsinan till and beneath loess at many places in the county. Outwash of sand and pebbly sand of Shelbyville age covers much of the area of Illinoian till west and south of the moraine in T. 22 N., R. 4 W., and elsewhere. This outwash ranges from less than 1 foot to about 3 feet thick and is overlain by 5 to 10 feet of loess.

Small lenses of sand and gravel enclosed in glacial till can be found at many outcrops. Outcrops of sand and gravel beneath thick till, and possibly more extensive than the ordinary intra-till lens, were seen along the Illinois Valley bluffs in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 12, T. 26 N., R. 4 W., and along the Mackinaw River in the SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 12, T. 23 N., R. 5 W. Both outcrops were too small to map.

Well records indicate that sand and gravel occurs beneath thick glacial till in much of the upland area of the county. It is closest to the surface in the valleys.

SAND AND GRAVEL INDUSTRY

The terraces west of the Illinois Valley bluffs, the intermediate-level terrace along the Mackinaw River, and the high-level terrace in the Farm Creek

Valley are the principal sources of sand and gravel in Tazewell County. The larger pits operating with fixed equipment during the summer of 1965 are listed in table 4. In addition, many gravel pits are worked periodically with portable equipment and many pits have not been worked in the past several years.

TABLE 4 - SAND AND GRAVEL PRODUCERS
HAVING FIXED EQUIPMENT IN TAZEWELL COUNTY

Company name	Location	Type of deposit
Concrete Materials Division, Martin-Marietta Corp.	NE¼ sec. 26, T. 25 N., R. 5 W.	Intermediate-level terrace in Illinois Valley
Concrete Materials Division, Martin-Marietta Corp.	SE¼ sec. 23, T. 24 N., R. 3 W.	Intermediate-level terrace along Mackinaw River upstream from Illinois Valley bluffs
R. A. Cullinan and Son	SW¼ sec. 34, T. 24 N., R. 3 W.	Intermediate-level terrace along Mackinaw River upstream from Illinois Valley bluffs
Peoria Concrete Construction Co.	SW¼ sec. 35, T. 26 N., R. 4 W.	High-level terrace in Farm Creek Valley
C. A. Powley Co.	S½ sec. 25, T. 26 N., R. 4 W.	High-level terrace in Farm Creek Valley

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CIRCULAR 399

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA

EXPLANATION

AREAS OF SAND AND GRAVEL

Map pattern 1. Sand and gravel generally more than 40 feet thick forming intermediate-level terraces in Illinois Valley. In general, the material becomes finer to the south. Overburden consists of silt and soil up to 10 feet thick or, in places, as much as 40 feet of dune sand. (Havana and Manito Terraces)

Map pattern 2. Sand and gravel generally more than 40 feet thick forming a high-level terrace in Illinois Valley. In general, the material becomes finer to the south. Overburden is 5 to 15 feet of silt, clay, and soil or, in places, dune sand as much as 40 feet thick. (Normal-Cropsey-Bloomington terrace)

Map pattern 3. Sand and gravel generally more than 40 feet thick forming low-level terraces in Illinois Valley. Some of the gravel is very coarse. Overburden is generally 3 to 10 feet of silt and soil, but sand dunes are present in some places. (Bath and Beardstown Terraces)

Map pattern 4. Sand and gravel generally 20 to 35 feet thick forming an intermediate-level terrace along Mackinaw River upstream from Illinois Valley bluffs. Overburden is 5 to 10 feet of silt and soil. (Normal-Cropsey-Bloomington terrace)

Map pattern 5. Sand and gravel generally 15 to 30 feet thick forming a high-level terrace in Farm Creek Valley. Overburden is 5 to 10 feet of silt and soil. (Outer Bloomington terrace)

Map pattern 6. Sand and gravel, probably 15 to 25 feet thick in most places, forming a low-level terrace along Mackinaw River upstream from Illinois Valley bluffs. Overburden is 5 to 10 feet of silt and soil.

Map pattern 7. Sand and gravel forming a high-level terrace in Mackinaw Valley upstream from Illinois Valley bluffs. About 25 feet thick near Mackinaw but generally less than 15 feet thick. Overburden consists of 5 to 10 feet of silt and soil. (Outer Bloomington terrace)

Map pattern 8. Sand and gravel cropping out beneath pebbly clay (glacial till) in valley bluffs. The clay overburden is very thick in the hills back from the valley bluff outcrops. The upper part of the deposit, as much as 30 feet thick, is interbedded sand and gravel with clay (till) and cemented gravel in places. The lower part is largely sand with a maximum exposed thickness of 30 feet. (Illinoian and pre-Illinoian outwash)

Map pattern 9. Upland sand and gravel generally less than 15 feet thick. Overburden is generally 5 to 10 feet of silt and soil. (Shelbyville, LeRoy, and Outer Bloomington outwash plains)

Map pattern 10. Sand and gravel generally less than 15 feet thick forming minor terraces of various ages.

AREAS OF SAND

Map pattern 11. Hills of sand more than 10 feet high, overlying sand and gravel, except where they occur on map pattern 14. (Sand dunes)

AREAS LARGELY OF SILT AND CLAY

Map pattern 12. Stream deposits consisting mainly of silt and clay but containing or overlying sand and gravel in places. (Alluvium)

HILLS OF SAND, GRAVEL, AND CLAY

Map pattern 13. Hills of sand, gravel, and pebbly clay (glacial till). (Kames)

AREAS GENERALLY DEVOID OF SAND AND GRAVEL

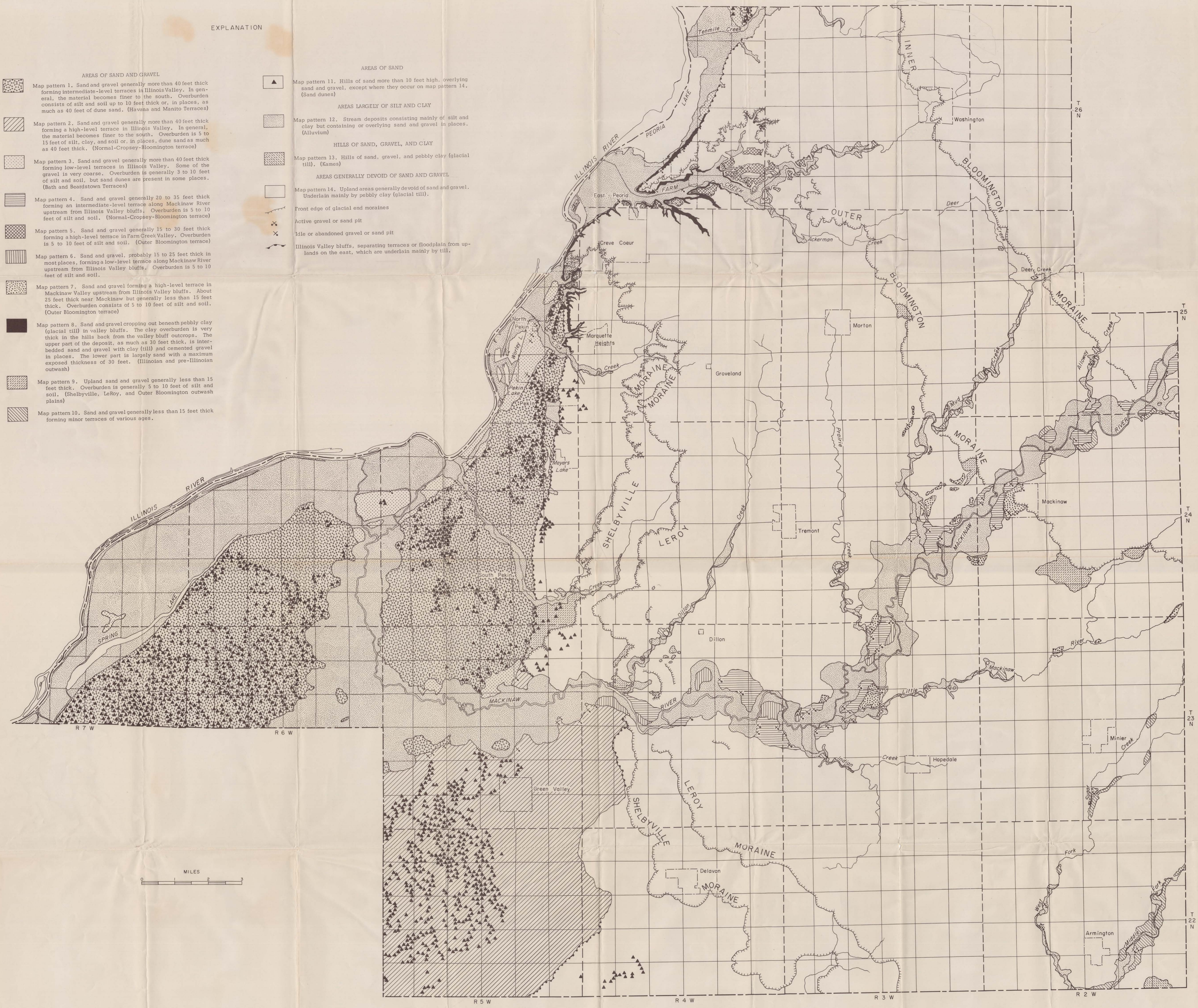
Map pattern 14. Upland areas generally devoid of sand and gravel. Underlain mainly by pebbly clay (glacial till).

Front edge of glacial end moraines

Active gravel or sand pit

Idle or abandoned gravel or sand pit

Illinois Valley bluffs, separating terraces or floodplain from uplands on the east, which are underlain mainly by till.



SAND AND GRAVEL RESOURCES OF TAZEWELL COUNTY

by

RALPH E. HUNTER

1966